PHILOSOPHICAL

TRANSACTIONS.

XVII. *On the proper Motion of the Sun and Solar Syſtem; with an Account of ſeveral Changes that have happened among the fixed Stars ſince the Time of Mr.* Flamſtead. *By* William Herſchel, *Eſq. F. R. S.*

Read March 6, 1783.

THE new lights that modern obſervations have thrown upon ſeveral intereſting parts of aſtronomy begin to lead us now to a ſubject that cannot but claim the ſerious attention of every one who wiſhes to cultivate this noble ſcience. That ſeveral of the fixed ſtars have a proper motion is now already ſo well confirmed, that it will admit of no further doubt. From the time this was firſt ſuſpected by Dr. HALLEY we have had continued obſervations that ſhew Arcturus, Sirius, Aldebaran, Procyon, Caſtor, Rigel, Altair, and many more, to be actually in motion; and conſidering the ſhortneſs of the time we have had obſervations accurate enough for the purpoſe, we may rather wonder that we have already been able to find the motions of ſo many, than that we have not diſcovered the like alterations in all the reſt. Beſides, we are well prepared to find numbers of them apparently at reſt, as, on account of their immenſe diſtance, a change of place cannot be expected to become viſible to us till after many ages of careful attention and cloſe obſervation, though every one of them ſhould have a motion of the ſame importance with Arcturus. This conſideration alone would lead us ſtrongly to ſuſpect, that there is not, in ſtrictneſs of ſpeaking, one *fixed* ſtar in the heavens; but many other reaſons, which I ſhall preſently adduce, will render this ſo obvious, that there can hardly remain a doubt of the general motion of all the ſtarry ſyſtems, and conſequently of the ſolar one among the reſt.

I might begin with principles drawn from the theory of attraction, which evidently oppoſe every idea of abſolute reſt in any one of the ſtars, when once it is known that ſome of them are in motion: for the change that muſt ariſe by ſuch motion, in the value of a power which acts inverſely as the ſquares of the diſtances, muſt be felt in all the neighbouring ſtars; and if theſe be influenced by the motion of the former, they will again affect thoſe that are next to them, and ſo on till all are in motion. Now as we know ſeveral ſtars, in divers parts of the heavens, do actually change their place, it will follow, that the motion of our ſolar ſyſtem is not a mere hypotheſis; and what will give additional weight to this conſideration is, that we have the greateſt reaſon to ſuppoſe moſt of thoſe very ſtars, which have been obſerved to move, to be ſuch as are neareſt to us; and, therefore, their influence on our ſituation would alone prove a powerful argument in favour of the proper motion of the ſun, had it actually been originally at reſt. But I ſhall wave every view of this ſubject which is not chiefly derived from experience.

To begin with my own, I will give a ſhort but general account of the moſt ſtriking changes I have found to have happened in the heavens ſince FLAMSTEAD's time. I have now almoſt finiſhed my third review. The firſt was made with a Newtonian teleſcope, ſomething leſs than 7 feet focal length, a power of 222, and an aperture of 4½ inches. It extended only to the ſtars of the firſt, ſecond, third, and fourth magnitudes. Of my ſecond review I have already given ſome account*: it was made with an inſtrument much ſuperior to the former, of 85,2 inches focus, 6,2 inches aperture, and power 227. It extended to all the ſtars in HARRIS's maps, and the teleſcopic ones near them, as far as the eighth magnitude. The catalogue of double ſtars, which I have had the honour of communicating to the Royal Society, and the diſcovery of the Georgium Sidus, were the reſult of that review. My third review was with the ſame inſtrument and aperture, but with a very diſtinct power of 460, which I had already experienced to be much ſuperior to 227, in detecting exceſſively ſmall ſtars, and ſuch as are very cloſe to large ones. At the ſame time I had ready at hand ſmaller powers to be uſed occaſionally after any particularity had been obſerved with the higher powers, in order to ſee the different effects of the ſeveral degrees of magnifying ſuch objects. I had alſo 18 higher magnifiers, which gave me a gradual variety of powers from 460 to upwards of 6000, in order to purſue particular objects to the full extent of

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* Phil. Tranſ. vol. LXX. LXXI. LXXII.

my teleſcope, whenever a favourable interval of remarkably fine weather preſented me with a proper opportunity for making uſe of them. This review extended to all the ſtars in FLAMSTEAD's catalogue, together with every ſmall ſtar about them, as far as the tenth, eleventh, or twelfth magnitudes, and occaſionally much farther, to the amount of a great many thouſands of ſtars. To ſhew the practicability of what I have here advanced, it may be proper to mention, that the convenient apparatus of my teleſcope is ſuch, that I have many a night, in the courſe of eleven or twelve hours of obſervation, carefully and ſingly examined not leſs than 400 celeſtial objects, beſides taking meaſures of angles and poſitions of ſome of them with proper micrometers, and ſometimes viewing a particular ſtar for half an hour together, with all the various powers of my teleſcope. The particularities I attended to in this laſt review were, 1. The exiſtence of the ſtar itſelf, ſuch as it is given in the Britiſh catalogue. 2. To obſerve well whether it was double or ſingle, well defined or hazy. 3. To view and mark down its particular colour, whenever the altitude and ſituation of the ſtar would permit it to be done with certainty. 4. To examine all the ſmall ſtars in the neighbourhood, as far at leaſt as the twelfth magnitude, and note the ſame particulars concerning them, except the colours, which would have taken up too much time in committing to paper, and be of no very material uſe. The reſult of theſe obſervations I ſhall collect under a few general heads in the following articles.

I.

Stars that are loſt, or have undergone ſome capital change, ſince FLAMSTEAD's time.

In the Britiſh catalogue we find two remarkable ſtars of the fourth magnitude in the conſtellation of Hercules, *viz.* the

80th and 81ſt. They are no more to be ſeen. I looked for them in October, 1781, but could not find them; and have ſince frequently examined that part of the heavens with no better ſucceſs, though the ſmall ſtars κ, z, y, of the ſixth magnitude, not far from the place where the former ſhould be, appear very plainly in a fine evening. On referring to my preceding review in Auguſt, 1780, I find, that I then alſo examined the left foot of Hercules, and had theſe ſtars been there at that time I muſt have ſeen them; for not only ι of the fourth magnitude, but y of the ſixth, is in the liſt of ſtars examined; and the place of the 80th and 81ſt is very near directly between them.

In the northern claw of Cancer FLAMSTEAD has placed three ſtars of the ſixth magnitude; they are the 53d, 55th, and 56th of his catalogue. The latter of them is vaniſhed. Its place and magnitude are ſo well pointed out by the other two ſtars, that there can remain no doubt of this remarkable change. We find a very ſmall teleſcopic ſtar near the place where the 56th ſhould be: this may poſſibly be the remains of that vaniſhing ſtar; but that may be aſcertained by thoſe aſtronomical gentlemen, who, having fixed inſtruments, can determine the place of this ſmall ſtar, and compare it with the 56th of Cancer, when it will appear how far their places agree. I miſſed it firſt in February, 1782, and have ſince looked often for it in vain.

The 19th Perſei, a ſtar of the 6th magnitude, is either loſt, or ſo conſiderably removed from its place in FLAMSTEAD's time, that it is no longer to be known. What gives occaſion for a ſuſpicion of its having been removed is, that we find no ſtar of the ſixth magnitude in the place where this ſhould be; whereas, about a degree following that ſituation, there is one of that, or the fifth magnitude, not taken notice of by FLAM-

STEAD, who could not overlook ſo conſiderable a ſtar if it had been there in his time; becauſe, being not far from the parallel of τ and υ, both which he has given us, it muſt have paſſed the field of view of his teleſcope whenever he obſerved them.

The 108th Piſcium, a ſtar of the ſixth magnitude, near the head of Aries is loſt. The 107th and 109th, both marked as ſmaller ſtars in FLAMSTEAD's catalogue, and near the place of the 108th, are eaſily diſcovered.

Two ſtars of the ſixth magnitude, the 73d and 74th Cancri, in the ſouthern claw, are either both loſt, or at leaſt have undergone ſuch a remarkable change of magnitude, and one of them of place, that it is hardly poſſible to know them any longer. The alteration muſt evidently appear when we compare them to the 81ſt and 82d Cancri; the former of which, though only marked of the 7th magnitude, far outſhines the brighteſt of thoſe which may be ſuppoſed to be the two ſtars in queſtion.

The 8th Hydræ is loſt. There is a ſtar juſt by, which I take to be the 31ſt Monocerotis. If this ſhould be the 8th Hydræ, and a ſmall ſtar near the latter ſhould agree with the place of th 31ſt Monocerotis, then the magnitudes will be quite contrary to what FLAMSTEAD makes them. There muſt, at all events, have been a very remarkable change.

The 26th Cancri is loſt. Near this ſtar is placed the 22d of the ſame conſtellation, and, as their diſtance is not much more than a quarter of a degree, it requires fixed inſtruments to determine which of the two is the ſtar wanting: from the magnitude, however, I ſurmiſe, that the remaining ſtar is the 22d rather than the 26th.

The 62d Orionis is loſt; and a ſtar near the 54th and 51ſt is not taken notice of by FLAMSTEAD. Perhaps the 62d has changed place; if this ſhould be the caſe, it muſt have a very conſiderable motion.

The 71ſt Herculis, a ſtar of the 5th magnitude, is loſt. The 70th and 71ſt are ſo near each other by FLAMSTEAD's catalogue, that it cannot be determined without fixed inſtruments, which is the ſtar wanting. There is a ſmall teleſcopic ſtar, within about 30 minutes north following, in a direction towards μ Lyræ; if that ſhould be the 71ſt, it is wonderfully changed both in place and ſize. The 40th ſtar in Mr. MAYER's collection of double ſtars * ſeems to be the 70th Herculis of FLAMSTEAD. Now, as that ſtar is perfectly ſingle in my teleſcope, with every power I have tried upon it, we may ſurmiſe that one of the ſtars which is now vaniſhed was ſtill viſible in the year 1778, when Mr. MAYER obſerved it, though then already diminiſhed from the 5th to the 8th magnitude.

The 34th Comæ Berenices is loſt: FLAMSTEAD has marked it as a ſtar of the 5th magnitude.

The 19th of the ſame conſtellation is alſo loſt, or moved and changed in magnitude.

The 40th and 41ſt Draconis have undergone ſo great an alteration of place that we cannot poſſibly miſtake it; for in FLAMSTEAD's time they were above three minutes aſunder, whereas now their diſtance is much leſs than half a minute. A more particular account of theſe two ſtars will be given in a ſecond collection of more than 400 new double ſtars, obſerved in my third review, which I hope ſoon to have the honour of preſenting to the Royal Society.

There ſeems to be an alteration in the place of the 65th, 64th, 54th, and 57th Orionis; but without fixed inſtruments I cannot aſcertain in which of the ſtars it is. Their ſituation in the heaven does not agree with that which is delineated in FLAMSTEAD's Atlas Cœleſtis, for theſe two pair of ſtars are

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* De novis in Cœlo ſidereo phænomenis.

much nearer now than they ſhould be, according to that account.

II.

Stars that have changed their magnitude ſince FLAMSTEAD's time.

α Draconis is ſo much leſs than β, which is ſet down as a ſmaller ſtar in FLAMSTEAD's catalogue, that the change of magnitude cannot be doubted.

β Ceti marked of the 3d, and α Ceti of the 2d, are evidently the reverſe, β being by much the larger ſtar. I have mentioned this circumſtance in my obſervations on the periodical ſtar in Collo Ceti *, and it ſeems now as if the difference between the magnitudes of theſe two ſtars was ſtill increaſing.

ζ Serpentis is not near ſo large as η, and yet we find FLAMSTEAD has placed them in the ſame claſs: however, we cannot intirely confide in the marks of the magnitudes when two ſtars are placed in the ſame claſs, ſince every order admits of a conſiderable variety; but when the marks contradict experience ſo far as to deſcribe one ſtar, for inſtance, of the third, and another of the 4th magnitude, when obſervation ſhews the latter to be of the 3d and the former of the 4th, I think we can hardly doubt but that there muſt have been a change.

η Cygni is a brighter ſtar than χ, though marked by FLAMSTEAD of a leſs magnitude.

The 2d Urſæ minoris is marked of the 6th magnitude, but is certainly intitled to the 5th.

η Bootis is much larger than ζ.

ι Delphini is much larger than κ.

β Trianguli is much larger than α.

γ Aquilæ is much larger than β.

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* Phil. Tranſ. vol. LXX. numb. XXI.

σ Sagittarii is larger than δ, γ, and ϵ, though marked of an inferior magnitude.

δ Canis majoris is larger than β, and yet is marked to be leſs.

η Serpentis is ſo much larger than ζ, that they certainly ſhould not have been put in the ſame order of magnitude.

κ Serpentarii is larger than γ and ϵ, though marked to be of a leſs magnitude than either.

β Equulei is ſo much leſs than α that it could hardly deſerve to be put in the ſame claſs.

δ Delphini is larger than ϵ, though placed in an inferior order.

ϵ Bootis is ſo much larger than ζ that it ſhould not be put into the ſame order.

δ Sagittæ is larger than α and β, though placed in a lower order of magnitude.

δ Urſæ majoris is leſs than either ϵ, ζ, or η, though it is marked of a ſuperior order of magnitude. Beſides, it is evidently viſible, that δ cannot be intitled to more than the 4th magnitude, or at moſt to between the 4th and 3d: on the contrary, ϵ, ζ and η, ſhould be of the 2d, or at leaſt between the 2d and 3d; all which is very different from FLAMSTEAD's account of thoſe remarkable ſtars.

α Urſæ majoris is leſs than any ſtar marked of the ſame magnitude, and cannot have the leaſt pretenſion to be called a ſtar of between the 1ſt and 2d, as FLAMSTEAD has marked it, and as I make no doubt it was in his time.

The 1ſt and 2d Hydræ are noted by FLAMSTEAD as being of the 4th magnitude, whereas they now are only of the 8th or 9th. It is remarkable, that the 30th Monocerotis, which is ſituated between them, has retained the order aſſigned to it by FLAMSTEAD, and being of the 6th ſerves to point out the change of the other two in a very evident manner.

γ Lyræ is much larger than β.

The change in the magnitudes of the 31ſt and 34th Draconis is very ſtriking, theſe two ſtars being juſt the contrary of what they are marked in FLAMSTEAD's catalogue. The 31ſt from the 7th is increaſed to the 4th; and the 34th, from being a ſtar between the 4th and 5th, is reduced to one of the 6th, if not 7th magnitude.

The 44th Cancri is much too ſmall for the 6th magnitude. As ε and others are marked of the 6th, this, on being compared to them, can be intitled to no more than the 8th or 9th order.

The 96th Tauri is ſmall enough to be of the 8th magnitude, though marked as one of the 6th.

The 62d Arietis is of the 5th magnitude, though only marked of the 6th.

The magnitudes of the 12th and 14th Lyncis are juſt the reverſe in the heavens to what FLAMSTEAD has marked them. This denotes a double change of a ſtar from the 5th to the 7th, and from the 7th to the 5th magnitude.

The 38th Perſei, marked of the 6th magnitude, is increaſed ſo as to be equal to θ and κ of the 4th. Alſo, θ is leſs than ι contrary to FLAMSTEAD.

The 8th Monocerotis is leſs than the 76th Orionis, though the former ſhould be of the 4th, and the latter only of the 6th magnitude.

The 23d Geminorum, though marked of the 5th, is leſs than the 21ſt of between the 6th and 7th magnitude.

The 26th Orionis is much too ſmall for the magnitude of which it is marked to be, or rather is loſt; for I can hardly take any one of the remaining teleſcopic ſtars for it.

ξ Leonis in FLAMSTEAD's time was of the 4th; but is now leſs than a ſtar of the 5th magnitude.

III.

Stars newly come to be viſible.

Near Lacerta's tail-end is a ſtar of between the 4th and 5th magnitude, not mentioned in FLAMSTEAD's catalogue, though the 1ſt Lacertæ, not far from that place, is recorded. It is ſo eaſy to be ſeen with the naked eye, and in a ſpot where but few ſtars of that magnitude are near, that we can hardly account for its being omitted if it had been viſible to FLAMSTEAD. Its colour is pale red.

The ſtar of the 5th magnitude following τ Perſei, ſuppoſed to be υ removed, is moſt likely new, unleſs future obſervations were to favour the ſuppoſed motion of this ſtar. It is among the double ſtars of my 4th claſs, ſo that it will be eaſy to detect its proper motion.

A very conſiderable ſtar, not marked by FLAMSTEAD, will be found near the head of Cepheus. Its right aſcenſion in time, is about 2′ 19″ preceding FLAMSTEAD's 10th Cephei, and it is about 2° 20′ 3″ more ſouth than the ſame ſtar. It is of a very fine deep garnet colour, ſuch as the periodical ſtar *o* Ceti was formerly, and a moſt beautiful object, eſpecially if we look for ſome time at a white ſtar before we turn our teleſcope to it, ſuch as α Cephei, which is near at hand.

A conſiderable ſtar in a direction from the 68th Geminorum towards the 61ſt is not to be found in FLAMSTEAD, its colour is red.

A ſtar of a conſiderable magnitude preceding the 1ſt Equulei is not contained in FLAMSTEAD's catalogue. It is a double ſtar of the firſt claſs, the 61ſt of my ſecond collection, where meaſures of it will be found.

A conſiderable ſtar following the 1ſt Sextantis, and another following the 7th, are not inſerted.

Between β Cancri and δ Hydræ is a very conſiderable ſtar not marked by FLAMSTEAD, though its ſituation is very remarkable. As the conſtellation of Cancer contains ſo rich a collection of very ſmall ſtars, it is to be wondered how a ſtar of ſuch conſequence could be omitted, if it had been viſible in FLAMSTEAD's time.

Nearly 1½ degree north following δ Herculis, almoſt in the direction of δ and ν, is a ſtar of the 5th, or between the 4th and 5th magnitude, very viſible to the naked eye. We can hardly think FLAMSTEAD could have overlooked it, had it been there in his time.

About 3 degrees ſouth preceding γ Bootis, a conſiderable ſtar not in FLAMSTEAD's catalogue of the 6th magnitude; and ſouth preceding λ, another, almoſt as large.

Here we ought to obſerve, that it is not eaſy to prove a ſtar to be newly come; for though it ſhould not be contained in any catalogue whatſoever, yet the argument for its former non-appearance, which is taken from its not having been obſerved, is only ſo far to be regarded as it can be made probable, or almoſt certain, that a ſtar would have been obſerved had it been viſible. For theſe reaſons I will lay no particular ſtreſs on the new appearance of the above ſtars; they are, however, ſuch as do well deſerve to have their places ſettled, while I ſhall leave it to others to determine how far they may think them to be new viſitors to thoſe ſtarry regions that fall within the reach of our ſight.

To return to the principal ſubject of this paper, which is the proper motion of the ſun and ſolar ſyſtem: does it not ſeem very natural, that ſo many changes among the ſtars,—many increaſing their magnitude, while numbers ſeem gradually to vaniſh;—ſeveral of them ſtrongly ſuſpected to be new-comers, while we are ſure that others are loſt out of our ſight;—the diſtance of many actually changing, while many more are ſuſpected to have a conſiderable motion:—I ſay, does it not ſeem natural that theſe obſervations ſhould cauſe a ſtrong ſuſpicion that moſt probably every ſtar in the heaven is more or leſs in motion? And though we have no reaſon to think, that the diſappearance of ſome ſtars, or new appearance of others, nor indeed the frequent changes in the magnitudes of ſo many of them are owing to their change of diſtance from us by proper motions, which could not occaſion theſe phenomena without being inconceivably quick; yet we may well ſuppoſe, that motion is ſome way or other concerned in producing theſe effects. A ſlow motion, for inſtance, in an orbit round ſome large opaque body, where the ſtar, which is loſt or diminiſhed in magnitude, might undergo occaſional occultations, would account for ſome of thoſe changes, while others might perhaps be owing to the periodical return of large ſpots on that ſide of the ſurface which is alternately turned towards us by a rotatory motion of the ſtar. The idea alſo of a body much flattened by a quick rotation, and having a motion ſimilar to the moon's orbit by a change of the place of its nodes, whereby more of the luminous ſurface would one time be expoſed to us than another, tends to the ſame end; for we cannot help thinking with Mr. DE LA LANDE (Mem. 1776), that the ſame force which gave ſuch rotations, would probably alſo occaſion motions of a different kind by a tranſlation of the center *. Now, if the proper motion of the ſtars in general be once admitted, who can refuſe to allow that our ſun, with all its planets and comets, that is, the ſolar ſyſtem, is no leſs liable to ſuch a general agitation as we find to obtain among all the reſt of the celeſtial bodies †.

Admitting this for granted, the greateſt difficulty will be how to diſcern the proper motion of the ſun between ſo many other (and variouſly compounded) motions of the ſtars. This is an arduous taſk indeed, which we muſt not hope to ſee accompliſhed in a little time; but we are not to be diſcouraged from the attempt. Let us, at all events, endeavour to lay a good foundation for thoſe who are to come after us. I ſhall therefore now point out the method of detecting the direction and quantity of the ſuppoſed proper motion of the ſun by a few geometrical deductions, and at the ſame time ſhew by an application of them to ſome known facts, that we have already ſome reaſons to gueſs which way the ſolar ſyſtem is probably tending its courſe.

Suppoſe the ſun to be at S, fig. 1.; the fixed ſtars to be diſperſed in all poſſible directions and diſtances around at *s*, *s*, *s*, *s*, &c. Now, ſetting aſide the proper motion of the ſtars, let us firſt conſider what will be the conſequence of a proper motion in the ſun; and let it move in a direction from A towards B.

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* Relating to the motion of the fixed ſtars, the Aſtronomer Royal has an expreſſion in the ſecond page of the explanation and uſe of the tables publiſhed in his Aſtronomical Obſervations, which ſeems to favour this idea, where he mentions the "peculiar but ſmall motions, which many, IF NOT ALL OF THEM, "have among themſelves, which have been called their *proper motions*, the cauſes "and laws of which are hid for the preſent in almoſt equal obſcurity."

† See Mr. MICHELL's note, Phil. Tranſ. vol. LVII. p. 252.

Suppoſe it now arrived at C. Here, by a mere inſpection of the figure, it will be evident, that the ſtars *s*, *s*, *s*, which were before ſeen at *a*, *a*, *a*, will now, by the motion of the ſun from S to C, appear to have gone in a contrary direction, and be ſeen at *b*, *b*, *b*; that is to ſay, every ſtar will appear more or leſs to have receded from the point B, in the order of the letters *ab*, *ab*, *ab*. The converſe of this propoſition is equally true; for if the ſtars ſhould all appear to have had a retrograde motion, with reſpect to the point B, it is plain, on a ſuppoſition of their being at reſt, the ſun muſt have a direct motion towards the point B, to occaſion all theſe appearances. From a due conſideration of what has been ſaid, we may draw the following inferences.

1. The greateſt or total ſyſtematical parallax of the fixed ſtars, fig. 2. will fall upon thoſe that are in the line DE, at rectangles to the direction AB of the ſun's motion.

2. The partial ſyſtematical parallax of every other ſtar, *s*, *s*, *s*, not in the line DE, will be to the total parallax as the ſine of the angle BS*a*, being the ſtars diſtance from that point towards which the ſun moves, to radius.

3. The parallax of ſtars at different diſtances will be inverſely as thoſe diſtances; that is, one half at double the diſtance, one third at three times, and ſo on; for the ſubtenſe SC remaining the ſame, and the parallactic angle being very ſmall, we may admit the angle S*s*C, to be inverſely as the ſide S*s*, which is the ſtars diſtance.

4. Every ſtar at reſt, to a ſyſtem in motion, will appear to move in a direction contrary to that in which the ſyſtem is moving.

Corollary. Hence it follows, that if the ſolar ſyſtem be carried towards any ſtar ſituated in the ecliptic: every ſtar, whoſe angular diſtance *in antecedentia* (reckoned upon the ecliptic from the ſtar towards which the ſyſtem moves) is leſs than 180 degrees, will decreaſe in longitude. And that, on the contrary, every ſtar, whoſe diſtance from the ſame ſtar (reckoned upon the ecliptic but *in conſequentia*) is leſs than 180 degrees, will increaſe in longitude, in both caſes without alteration of latitude.

From theſe principles it would be eaſy to draw general theorems for every poſſible direction of the motion of the ſolar ſyſtem, by which we might find what alteration of longitude or latitude would take place in any given ſtar; but it will be time enough for thoſe inveſtigations when we ſhall have more immediate occaſion for them. What we are now chiefly to endeavour at is, the ſpeedy method of obtaining ſufficient facts to proceed upon.

The immenſe regions of the fixed ſtars may be conſidered as an infinitely expanded globe, having the ſolar ſyſtem for its center. With this idea it will occur to us, that no method can be ſo proper for finding out the direction of the motion of the ſun as to divide our obſervations on the ſyſtematical parallax of the fixed ſtars into three principal zones. Theſe, for the convenience of fixed inſtruments, may be aſſumed ſo as to let them paſs around the equator and the equinoctial and ſolſtitial colures, every one being at rectangles to the other two, according to the three dimenſions of ſolids. And ſince no obſervations can be ſo conveniently made to aſcertain ſmall relative proper motions among the fixed ſtars as thoſe on double ſtars, I have continued my reſearches in that line with great application, and can now furniſh out theſe three zones, with a very complete ſet of double ſtars for ſuch obſervations. We have the greateſt reaſon to hope for ſucceſs in this attempt; for, if I am not miſtaken, there will be found a ſecular ſyſtematical parallax of ſome conſiderable value; nay, poſſibly, ſo ſhort a ſpace of time as ten years may ſuffice to bring us acquainted with many hitherto unknown celeſtial motions.

The equatorial zone, extending 10 degrees on each ſide of the equator, will contain about 150 ſtars which I have found to be double, *viz.*

Piſcium 38. 51. 77. 86. north of 110. 113.

Ceti ſouth of 13. foll. 25. 26. 37. north of 37. foll. 54. 61. 66.

Eridani 32. near 48. 62. 69.

Tauri near 10. 45. foll. 66. 88.

Orionis foll. 1. near 10. foll. 10. 19. pre. 20. 20. 23. near 26. 28. near 28. pre. 29. near 30. between 30 and 33. 32. 33. 34. foll. 34. pre. 36. 39. 41. near 42. 44. another 44. pre. 46. north of 46. foll. 47. 48. 50. 52. pre. 58. 58. 59.

Monocerotis 8. 11. near 11. In naribus. Sub genam. Inter pedes. near 12. foll. 15. pre. 25. foll. 25. 29. 31. near 31.

Canis minoris near 10. foll. 10. 14.

Cancri 17.

Hydræ pre. 4. pre. 4. foll. 4. 15. 17. pre. 22. 22. foll. 22. 27. 30. 31.

Leonis 3. foll. 3. pre. 43. ſouth of 43. 57. foll. 63. 74. pre. 75. 83. 84.

Virginis 4. 17. 25. 29. pre. 44. 44. 51. 51. 84. pre. 93. 93.

Libræ 17. near 31.

Serpentis 58. 59. 63.

Serpentarii near 11. 53. 61. 67. ſouth of 67. 70.

Aquilæ 2. near 6. near 6. pre. 7 and 8. 15. 24. pre. 30 near 35. near 35. 49. 53. near 54. 57. near 63. 64. near 65. near 65.

Delphini 1.

Aquarii 4. 4. 22. 24. 51. 55. ſouth of 72.

Equulei 1. pre. 1. ſouth of 2. ſouth of 6. 7.

Pegaſi 3. near 3. 8. near 18.

Piſcium near 7. 8. ſouth of 10. 35.

Ceti ſouth of 4.

The zone of the equinoctial colure, extending 10 degrees of a great circle on each ſide, will contain, as far as it is viſible in our hemiſphere, about 70 double ſtars, *viz.*

Ceti foll. 4. near 13.

Aquarii 107.

Piſcium 51. 38. 35. 76.

Andromedæ 21. Supra caput. 29. pre. 23. near 27. near 16. near 17.

Caſſiopeæ pre. 25. prec. 25. 8. 24. 18. 6. 9. ſouth of 11. 55. 34. 31. 4. 3. 2. near 33. 35. 36. near 3. 44. 47.

Cephei 1. foll. 32. foll. 32. foll. 31.

Urſæ minoris 1. 18.

Draconis 40 and 41. between 10 and 11. near 77.

Urſæ majoris 79. between 50 and 38. foll. 42. 65. 57. near 58. ſouth of 69.

Canum venaticorum 12. 2.

Comæ Berenices 24. from 36 to 26. 2. 12.

Leonis 95. 90. 93. pre. 95.

Virginis 29. pre. 44. between 4 and 6. 17. 25. 27. ſouth of 12. 4.

Corvi 7.

Crateris 17. foll. 21.

The zone of the ſolſtitial colure, of the ſame extent, will include about 120 double ſtars, *viz.*

Canis majoris north of 13. 17. foll. 5. foll 2. foll. 5.

Monocerotis 11. 8. 12. near 11. In naribus. foll. 15. Inter pedes. Sub genam.

Leporis 13.

Orionis 48. near 42. 41. 44. 44. 50. foll. 72. 58. In fuſte. 59. pre. 70 and 76. pre. 58. pre. 69.

Geminorum 43. 38. pre. 1. between 13 and 18. 21. 15. north of 19. 12. near 34. 27. 37. near 24. near 24. ſouth of 18. foll. 13 and 18.

Tauri north of 123.

Aurigæ 29. 13. 37. 34. 32. ſouth of 34. 56. near 59. pre. 58. pre. Nebulam. 41.

Lyncis 12. In naribus. 5. 13. In pectore. 19.

Camelopardali. In aure.

Urſæ minoris 1. near 18. near 12.

Draconis 39. 63. 19. 21. 56. 31. 47. 24 and 25. 69. 46. near 31. 40 and 41. 48. near 23. near 77.

Cephei 1. 8.

Herculis 75. 95. over 85. near 87. 100. 86. near 94. near 103.

Lyræ 4. 5. 6. 10. 3. 8. 11. near 3. near 6 and 7. foll. 5. foll. 10. pre. 10. pre. 14 and 15.

Serpentarii 70. 54. 61. 53. 67. near 67. north of 72. north of 72.

Serpentis 59. 63. 58.

Aquilæ near 7 and 8. 2. near 6. near 6.

Sagittarii 13. 38.

It will not be amiſs to add a zone of the ecliptic, which will contain, among others, a great many double ſtars that may undergo occultations by the moon or planets. This is of the ſame extent, and includes about 120 double ſtars.

Arietis north of 3. 5. pre. 6. north of 6. pre. 17. 30. 42. pre. 54. foll. 62. pre. 63. foll. 63. foll. 63. foll. 63.
Tauri near 4. 7. pre. 8. foll. 11. 30. 52. 59. 62. 68. foll. 68. pre. 74. 87. 94. 103. north of 103. 105. 111. foll. 112. 114. foll. 117. 118. north of 123. κ.
Orionis 68. pre. 69. pre. 70 and 76.
Aurigæ 14. 26. pre. Nebulam.
Geminorum pre. 1. 4. 12. foll. 13 and 18. 15. 18. 21. pre. 24. near 24. near 24. 27. 37. 38. 54. foll. 55. pre. 61. 63. north of 63. 66. 78. foll. 78. foll. 81.
Cancri 11. 16. foll. 16. 22. 23. 24. 30. 48. 54. pre. 77. ω foll. ι.
Leonis 2. 3. foll. 3. 6. 7. 14. 25. 32. 41. ſouth of 43. pre. 43. foll. 44 57. foll. 63. 74. pre. 75. 83. 84.
Virginis 4. foll. 4. pre. 4. 17. 25. 44. 51.
Hydræ 54.
Libræ pre. 12. 18. 24. 31. 51.
Scorpii 8. 14.
Serpentarii 5. 38. 39.
Sagittarii 13. 38. foll. 43. 64. near 65.
Capricorni north of 1. 5. 7. 9. 11. 12. near 29. 29. 39.
Aquarii 14. 22. foll. 43. 51. 55. 57. 70. 71. 72. 91. 94.
Piſcium near 7. ſouth of 8. 35. 38. 51. 77. 86. 110. 113.
Ceti foll. 4. near 13. 26. 54.

An account of each of theſe double ſtars, not already in my firſt catalogue, will be contained in the ſecond collection. It remains now only for me to make an application of this theory to ſome of the facts we are already acquainted with, relating to the proper motion of the ſtars. And firſt let me obſerve, that the rules of philoſophizing direct us to refer all phenomena to as few and ſimple principles as are ſufficient to explain them. Thus, for inſtance, we ſee the ſtars and planets riſe and ſet every day: now, as it is much more ſimple to admit the earth to turn once in 24 hours, than to ſuppoſe every ſingle ſtar to revolve round the earth in that time, we very juſtly aſcribe a diurnal motion to the earth; but yet, ſince we find that the planets do not every night exactly retain their relative places among the ſtars, we next admit that ſuch deviations from the law, which all the reſt ſeem to obey, are owing to a proper motion of their own. To apply this to the ſolar ſyſtem.— Aſtronomers have already obſerved what they call a proper motion in ſeveral of the fixed ſtars, and the ſame may be ſuppoſed of them all. We ought, therefore, to reſolve that which is common to all the ſtars, which are found to have what has been called a proper motion, into a ſingle real motion of the ſolar ſyſtem, as far as that will anſwer the known facts, and only to attribute to the proper motion of each particular ſtar the deviations from the general law the ſtars ſeem to follow in thoſe movements.

By Dr. MASKELYNE's account of the proper motion of ſome principal ſtars*, we find that Sirius, Caſtor, Procyon, Pollux, Regulus, Arcturus, and α Aquilæ, appear to have reſpectively the following proper motions in right aſcenſion. −0″,63; −0″,28; −0″,80; −0″,93; −0″,41; −1″,40; and +0″,57; and two of them, Sirius and Arcturus, in declination, *viz.* 1′,20 and 2″,01, both ſouthward. Let fig. 3. repreſent an equatorial zone, with the above mentioned ſtars referred to it, according to their reſpective right aſcenſions,

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[*] Aſtronomical Obſervations made at the Royal Obſervatory at Greenwich.

having the ſolar ſyſtem in its center. Aſſume the direction AB from a point ſomewhere not far from the 77th degree of right aſcenſion to its oppoſite 257th degree, and ſuppoſe the ſun to move in that direction from S towards B; then will that one motion anſwer that of all the ſtars together: for if the ſuppoſition be true, Arcturus, Regulus, Pollux, Procyon, Caſtor, and Sirius, ſhould appear to decreaſe in right aſcenſion, while α Aquilæ, on the contrary, ſhould appear to increaſe. Moreover, ſuppoſe the ſun to aſcend at the ſame time in the ſame direction towards ſome point in the northern hemiſphere, for inſtance, towards the conſtellation of Hercules; then will alſo the obſerved change of declination of Sirius and Arcturus be reſolved into the ſingle motion of the ſolar ſyſtem. I am well aware of the many yet remaining difficulties, ſuch as the correſpondence of the exact quantity of each ſtar's obſerved proper motion with the quantity that will be aſſigned to it by this hypotheſis; but we ought to remember, that the very different and ſtill unknown relative diſtances of the fixed ſtars muſt, for a good while yet, leave us in the dark about the particular and ſtrict application of the theory; and that any deviation from it may eaſily be accounted for by the ſtill unknown *real* proper motion of the ſtars: for if the ſolar ſyſtem have the motion I aſcribe to it, then what aſtronomers have already obſerved concerning the change of place of the ſtars, and have called their proper motion, will become only an *apparent* motion; and it will ſtill be left to future obſervations to point out, by the deviations from the general law which the ſtars will follow in thoſe apparent motions, what may be their real proper motions as well as relative diſtances. But leſt I ſhould be cenſured for admitting ſo new and capital a motion upon too ſlight a foundation,

dation, I muſt obſerve, that the concurrence of thoſe ſeven principal ſtars cannot but give ſome value to an hypotheſis that will ſimplify the celeſtial motions in general. We know that the ſun, at the diſtance of a fixed ſtar, would apppear like one of them; and from analogy we conclude the ſtars to be ſuns. Now, ſince the apparent motions of theſe ſeven ſtars may be accounted for, either by ſuppoſing them to move juſt in the manner they appear to do, or elſe by ſuppoſing the ſun alone to have a motion in a direction, ſomehow not far from that which I have aſſigned to it, I think we are no more authoriſed to ſuppoſe the ſun at reſt than we ſhould be to deny the diurnal motion of the earth, except in this reſpect, that the proofs of the latter are very numerous, whereas the former reſts only on a few though capital teſtimonies. But to proceed: I have only mentioned the motions of thoſe ſeven principal ſtars, as being the moſt noticed and beſt aſcertained of all; I will now adduce a farther confirmation of the ſame from other ſtars.

M. DE LA LANDE gives us the following table of the proper motion of 12 ſtars, both in right aſcenſion and declination, in 50 years *.

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* Aſt. par M. DE LA LANDE, tom. IV. p. 685.

Etoiles.	Chang. d'aſc. droite.		Chang. de déclinaiſon.	
	′	″	′	″
Arcturus	− 1	11	− 1	55
Sirius	−	37	−	52
β Cygni	−	3	+	49
Procyon	−	33	−	47
ε Cygni	+	20	+	34
γ Arietis	−	14	−	29
γ Gemin.	−	8	−	24
Aldébaran	+	3	−	18
β Gemin.	−	48	−	16
γ Piſcium	+	53	+	7
α Aquilæ	+	32	−	4
α Gemin.	−	24	−	1

Fig. 4. repreſents them projected on the plane of the equator. They are all in the northern hemiſphere, except Sirius, which muſt be ſuppoſed to be viewed in the concave part of the oppoſite half of the globe, while the reſt are drawn on the convex ſurface. Regulus being added to that number, and Caſtor being double, we have 14 ſtars. Every ſtar's motion, except Regulus, is aſſigned in declination as well as in right aſcenſion, ſo that we have no leſs than 27 motions given to account for. Now, by aſſuming a point ſomewhere near λ Herculis, and ſuppoſing the ſun to have a proper motion towards that part of the heaven, we ſhall ſatisfy 22 of theſe motions. For β Cygni, α Aquilæ, ε Cygni, γ Piſcium, γ Arietis, and Aldebaran, ought, upon the ſuppoſed motion of the ſun, to have an apparent progreſſion, according to the hour circle XVIII, XIX, XX, &c. or to increaſe in right aſcenſion, while Arcturus, Regulus, the two ſtars of α Geminorum, Pollux, Procyon, Sirius, and γ Geminorum, ſhould apparently

go back in the order XVI, XV, XIV, &c. of the hour circle, ſo as to decreaſe in right aſcenſion; but according to M. DE LA LANDE's table, excepting β Cygni and γ Arietis, all theſe motions really take place. With regard to the change of declination, we ſee that every ſtar in the table ſhould go towards the ſouth; and here we find but three exceptions in β and ε Cygni, and γ Piſcium; ſo that upon the whole we have but five deviations out of 27 known motions which this hypotheſis will not account for. And theſe exceptions muſt be reſolved into the real proper motion of the ſtars.

There are alſo ſome very ſtriking circumſtances in the quantities of theſe motions that deſerve our notice. Firſt, Arcturus and Sirius being the largeſt of the ſtars, and therefore probably the neareſt, ought to have the moſt apparent motion, both in right aſcenſion and declination, which is agreeable to obſervation, as we find by the table. Next, in regard to the right aſcenſion only, Arcturus being better ſituated to ſhew its motion, by theorem II. p. 261. ought to have it much larger, which we find it has. Aldebaran, both badly ſituated and conſiderably ſmaller than the two former, by the ſame theorem ought to ſhew but little motion. Procyon, better ſituated than Sirius, though not quite ſo large, ſhould have almoſt as much motion; for by the third theorem, on ſuppoſing it farther off becauſe it appears ſmaller, the effect of the ſun's motion will be leſſened upon it; whereas, on the other hand, by the ſecond theorem, its better ſituation will partly compenſate for its greater diſtance. This again is conformable to the table. ε Cygni very favourably ſituated, though but a ſmall ſtar, ſhould ſhew it conſiderably as well as α Aquilæ; whereas β Cygni ſhould have but little motion: and γ Piſcium, beſt ſituated of all, ſhould have a great increaſe of right aſcenſion, and theſe deductions alſo agree with the table.

In the laſt place, a very ſtriking agreement with the hypotheſis is diſplayed in Caſtor and Pollux. They are both pretty well ſituated, and we accordingly find that Pollux, for the ſize of the ſtar, ſhews as much motion in right aſcenſion as we could expect; but it is remarkable, and ſeemingly contrary to our hypotheſis, that Caſtor, equally well placed, ſhews by the table no more than one half of the motion of Pollux. Now, if we recollect that the former is a double ſtar, conſiſting of two ſtars not much different in ſize, we can allow but about half the light to each of them, which affords a ſtrong preſumption of their being at a greater diſtance, and therefore their partial ſyſtematical parallax, by the third theorem, ought to be ſo much leſs than that of Pollux, which agrees wonderfully with obſervation *. Not to mention the great difficulty in which we ſhould be involved, were we to ſuppoſe the motion of Caſtor to be really in the ſtar: for how extraordinary muſt appear the concurrence, that two ſtars, namely thoſe that make up this apparently ſingle ſtar, ſhould both have a proper motion ſo exactly alike, that in all our obſervations hitherto they have not been found to diſagree a ſingle ſecond, either in right aſcenſion or declination, for fifty years together! Does not this ſeem ſtrongly to point out the common cauſe, the motion of the ſolar ſyſtem?

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* If the light of Caſtor was exactly equal to that of Pollux, and the two ſtars, which make up the former ſtar, were perfectly of the ſame ſize, we might, on that account, ſuppoſe the diſtance of Caſtor from us to be to that of Pollux as $\sqrt{2} : 1$; but Caſtor is in fact ſomething leſs bright; and this conſideration, added to the former, will make it probable enough that its diſtance may perhaps be double that of Pollux.

With reſpect to the change of declination I would obſerve, that the point of λ Herculis, which in fig. 4. is aſſumed as the Apex [*] of the ſolar motion is not perhaps the beſt ſelected. A ſomewhat more northern ſituation may agree better with the changes of declination of Arcturus and Sirius, which capital ſtars may perhaps be the moſt proper to lead us in this hypotheſis; but as we ſhould be guided by facts in reſearches of this nature, it may be as well to expect the aſſiſtance of future obſervations before we are too particular in determining this point [†].

It may be expected I ſhould alſo mention ſomething concerning the quantity of the ſolar motion; but here I can only offer a few diſtant hints. From the annual parallax of the fixed ſtars, which, from my own obſervations, I find much leſs than it has hitherto been proved to be, we may certainly admit (without entering into a ſubject which I reſerve for a future opportunity) that the diameter of the earth's orbit, at the diſtance of Sirius or Arcturus, would not nearly ſubtend an angle of one ſecond; but the apparent motion of Arcturus, if owing to a tranſlation of the ſolar ſyſtem, amounts to no leſs than 2″,7 a year, as will appear if we compound the two motions of 1′ 11″ in right aſcenſion, and 1′ 55″ in declination, into one ſingle motion, and reduce it to an annual quantity.

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[*] I uſe the term Apex here to denote that point of fig. 4. wherein all great circles, drawn through the ſuppoſed direction of the motion of the ſolar ſyſtem, interſect, and which, in other ſtereographic projections, is generally a pole, either of the ecliptic or equator. As this point is in the northern or elevated hemiſphere, the ſun, by tending to it, may be ſaid to aſcend, and the term Apex may perhaps not be an improper one.

[†] From the additional teſtimony of other capital ſtars conſidered in the poſtſcript it now appears, that the point of λ Herculis is probably as well choſen as any we can fix upon in that part of the heavens.

Hence we may in a general way eſtimate, that the ſolar motion can certainly not be leſs than that which the earth has in her annual orbit.

I have now only to add, that it is to be expected future obſervations will ſoon throw more light upon this intereſting ſubject, and either fully eſtabliſh or overturn the hypotheſis of the motion of the whole ſolar ſyſtem. To this end I have already begun a ſeries of obſervation upon ſeveral zones of double ſtars; and ſhould the reſult of them be againſt theſe conjectures, I ſhall be the firſt to endeavour to point out the fallacy of them.

Datchet near Windſor,
Feb. 1, 1783.

Poſtſcript to the Paper on the Motion of the Solar Syſtem.

In my paper on the Motion of the Solar Syſtem, I uſed a table of the proper motion of ſome fixed ſtars, which M. DE LA LANDE has given us as an extract from TOB. MAYER's Opera inedita. By the favour of my aſtronomical friend Mr. AUBERT, I am now furniſhed with the ſcarce edition of the original. This work contains a catalogue of the place of 80 ſtars, obſerved by Mr. MAYER in 1756, and compared with the ſame ſtars as given by ROEMER in 1706. From the goodneſs of the inſtrument with which the obſervations to which Mr. MAYER has compared his own were made, he gives it as his opinion, that where the diſagreement in the place of a ſtar is but ſmall, it may be attributed to the imperfection of the inſtrument; but that when it amounts to 10 or 15″, it is a very probable indication of a proper motion of ſuch a ſtar. He adds, that when the diſagreement is ſo much as in ſome ſtars which he names, (among which is FOMAHAND, where the difference is 21″ in 50 years) he has not the leaſt doubt of a proper motion *.

By this extenſive table I thought it highly neceſſary immediately to examine the hypotheſis of the motion of the ſolar ſyſtem, that it might receive an early check from obſervations, if they ſhould be unfavourable; or that, on the other hand, it might be ſupported by the additional evidence of more ſtars, if their apparent proper motions ſhould coincide with the idea I have pointed out in my paper on this ſubject.

I have followed Mr. MAYER's judgement of his own and ROEMER's obſervations, and left out of the liſt all the ſtars that do not ſhew a diſagreement amounting to 10″ in the places which are given for them in 1706 and 1756. I have alſo left out thoſe 13, or rather 14 ſtars, which have already been examined in my paper, and have been ſhewn to ſupport the hypotheſis I have advanced: the reſt are here drawn up in two tables. The firſt contains the ſtars that agree with my aſſigned motion of the ſolar ſyſtem; or rather which are thereby reſolved into apparent, or partly apparent, and partly proper motions. The ſecond table contains thoſe ſtars whoſe motions cannot be accounted for by my hypotheſis, and muſt therefore be aſcribed to a real motion in the ſtars themſelves, or to ſome *ſtill more hidden* cauſe of a *ſtill remoter* parallax †.

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* De motu fixarum proprio Commentatio. Op. ined. Vol. I. p. 79.

† That I may not be obſcure, it will be proper to mention what I allude to, eſpecially as it claims a diſtant connection with our ſubject, and may hereafter become of ſufficient moment to engage our attention. Mr. MICHELL's admirable

idea of the ſtars being collected into ſyſtems (Phil. Tranſ. vol. LI, p. 249.) appears to be extremely well-founded, and is every day more confirmed by obſervations: though this does not, in my opinion, take away the probability of many ſtars being ſtill as it were *ſolitary*, or, if I may uſe the expreſſion, *interſyſtematical.* It occurs then naturally, that by the principle of gravitation, which is never at reſt, and which we have no reaſon to doubt extends to all poſſible diſtances, one ſyſtem of ſtars will act on another as if the ſtars of each ſyſtem were all collected into the center of gravity of each reſpective ſyſtem. Hence then will ariſe this evident conſequence, that a ſtar, or ſun, ſuch as ours, may have a proper motion within its own ſyſtem of ſtars, while at the ſame time the whole ſtarry ſyſtem to which it belongs may have another proper motion, totally different in quantity and direction. It will require no little abſtract conſideration to conceive the poſſibility of what may be thus ſurmiſed; therefore an inſtance or two, to elucidate the matter, may not be improper. If an inhabitant of the 5th ſatellite of Saturn ſhould have diſcovered, that his little world revolves at a great diſtance round a planet, and to his great aſtoniſhment ſhould alſo have found, that this planet again revolves round the ſun;—if, farther, our hypotheſis of the ſolar motion ſhould prove to be well-founded (which, in ſome of the ſtars, ſuppoſing them to be ſuns ſurrounded with planets and ſatellites, muſt certainly be the caſe); then a third capital motion will be introduced to this inhabitant of Saturn's ſatellite; and he will experience, in a narrow compaſs, what we now ſurmiſe may poſſibly be our caſe upon a more extended ſcale, by the motion of the whole ſyſtem of ſtars to which our ſun may belong. Another view may, perhaps, ſtill better throw a light upon the ſubject. Let us admit that a very ſmall nebula may be a collection of a thouſand ſtars: and if Mr. MICHELL's opinion of our ſyſtem of ſtars, which he aſſumes to be about a thouſand (Phil. Tranſ. vol. LVII. p. 255.) has any foundation, all theſe ſtars taken together will only ſubtend an angle of barely a minute to an eye placed 3438 times as far from the center of the ſyſtem as the two fartheſt ſtars in it are from each other. Now as I have found ſome of theſe nebulæ that are ſo ſmall, that a tolerably good teleſcope cannot diſtinguiſh them from a ſingle ſtar, whole ſyſtems of ſtars, when preſented to our imagination under this diminutive ſhape of nebulæ, will eaſily, I believe, be admitted among the number of thoſe celeſtial bodies that may have a proper motion. I ought to carry this hint a little farther, juſt to ſhew that it may poſſibly be applied to the ſubject of reſolving a number of concurrent proper motions of the fixed ſtars into apparent ones; and thereby, in proceſs of time, to arrive at the knowledge of all the real complicated motions of the planet we inhabit; of the ſolar ſyſtem

TABLE I.

Names of ſtars.	Motion in R.A.	Motion in Decl.	Names of ſtars.	Motion in R. A.	Motion in Decl.
β Ceti	+32		ζ Hydræ	−23	
α Arietis	+10		γ Leporis		−10
δ Ceti	+15		ε Urſæ majoris	−33	+10
α Ceti	+16		α Serpentarii	inſenſ.	
α Perſei	+16		γ Draconis	+12	
η Pleïadum		−16	α Lyræ	inſenſ.	+14
γ Eridani	+14		γ Aquilæ		−20
ε Tauri		−11	γ Capricorni	+19	
α Aurigæ	+11	−11	ε Pegaſi		−28
β Orionis	inſenſ.	inſenſ.	δ Capricorni	+24	−17
β Tauri	−11	−13	α Aquarii	+13	
α Orionis	inſenſ.	−11	ζ Pegaſi		−13
μ Geminorum	−16		Fomahand	+21	
ρ Navis	−13	−11	β Pegaſi	+12	
β Cancri		−14	α Andromedæ		−21
ι Urſæ majoris	−54		β Caſſiopeæ	+34	

to which it belongs; and even of the ſidereal ſyſtem, of which this ſun may poſſibly be a member. We ſee then, that while the ſun, by a proper motion, is going towards a certain point of the heavens, each of the ſtars belonging to the ſidereal ſyſtem, of which the ſun is one, ſuppoſing them to be relatively at reſt, with reſpect to each other, will be affected in the manner I have ſhewn (p. 261, &c. of the Paper on the proper Motion of the Sun) notwithſtanding the whole ſyſtem ſhould have a real motion in abſolute ſpace, and change its ſituation with reſpect to other ſyſtems or interſyſtematical ſtars. We ſee alſo, that with reſpect to ſtars not belonging to our ſyſtem, no parallax can appear but what is compounded of the proper motion of the ſun, and of the whole ſyſtem to which it belongs. And ſhould there ever be found, in any particular part of the heavens, a concurrence of proper motions of quite a different direction, we ſhall then, perhaps, begin to form ſome conjectures beſides thoſe already mentioned by Mr. MICHELL (p. 253. of the ſame volume of Tranſactions) which ſtars may poſſibly belong to ours, and which to other ſyſtems.

TABLE II.

Polaris		+13	ζ Hydræ		+24
γ Ceti	−14		α Hydræ		+13
β Perſei	−10		β Herculis	+14	
α Leporis		+11	γ Cygni	−13	
μ Geminorum		+15	ε Pegaſi	−14	
ε Canis majoris		+10	ζ Pegaſi	−20	

From the firſt table we gather, that the principal ſtars, Lucida Lyræ, Capella, α Orionis, Rigel, Fomahand, α Serpentarii, α Aquarii, α Arietis, α Perſei, α Andromedæ, β Tauri, β Ceti, and twenty more of the moſt diſtinguiſhed of the ſecond and third rank of ſtars, agree with our propoſed ſolar motion; when, on the contrary, the ſecond table contains but a few ſtars, and not a ſingle one of the firſt magnitude amongſt them to oppoſe it. It is alſo remarkable, that many ſtars of the firſt table agree both in right aſcenſion and declination with the ſuppoſition of a ſolar motion, whereas there is not one among thoſe of the ſecond table which oppoſes it in both directions. This ſeems to indicate that the ſolar motion, in ſome of them at leaſt, has counter-acted, and thereby deſtroyed the effect of their own proper motion in one direction, ſo as to render it inſenſible; otherwiſe it would appear improbable, that eight ſtars out of twelve, contained in the latter table, ſhould only have a motion at rectangles, or in oppoſition to any one given direction. The ſame may alſo be ſaid of nineteen ſtars among thoſe of the former table, that only agree with the ſolar motion one way, and are as to ſenſe at reſt in the other direction; but theſe ſingularities will not be near ſo remarkable when we have the motion of the ſun to compound with their own proper motions. However, I forbear entering too much into refined conſideration; what we are chiefly to determine at preſent is, an outline or ſketch of what many repeated, and farther extended, obſervations muſt ripen ſo far as in time to enable us to apply more particular calculations.

The motions of α Lyræ and ε Urſæ majoris towards the north are placed in the firſt table; it will, therefore, be proper to ſhew the general law by which the apparent declinations of the ſtars, at preſent under conſideration, are governed. Let an arch of 90 degrees be applied to a ſphere repreſenting the fixed ſtars, ſo as always to paſs through the apex of the ſolar motion: then, while one end of it is drawn along the equator, the other will deſcribe, on the ſpherical ſurface, a curve which will paſs through the pole of the equator, and return into itſelf at the apex. This curve, to borrow a term from natural hiſtory, is a *non-deſcript* as far as I can find at preſent, and may be called a ſpherical conchoid from the manner of its generation. The law then is, that all the ſtars in the northern hemiſphere, ſituated within the nodated part of the conchoid, will ſeem to go to the north by the motion of the ſolar ſyſtem towards its apex; the reſt will appear to go ſouthwards. A ſimilar curve is to be delineated in the ſouthern hemiſphere, in the nodated part of which the ſame appearances will take place. It will require but little attention to ſee the truth of this conſtruction.

Suppoſe the great circle A*cam*, fig. 5. of which the generating quadrant *mn* is a part, compleated; then will it interſect the equator EQT in two oppoſite points *me*. Now, ſince the apex A, by the hypotheſis, is ſomewhere north of the equator, the great circle will always make ſome angle A*m*Q with it; and the point *n*, which is 90 degrees from the interſection *m* with the equator, will be the moſt northern part of the ſemicircle *mnc*. From what has been ſaid (p. 261. of the paper on the Motion, &c.) it follows, that the apparent motion of any ſtar *s*S will always be in an arch of a great circle A*s*S*c* drawn through the apex A and ſtar *s*S: therefore, if the ſtar be leſs than 90 degrees of the generating circle diſtant from its interſection with the equator (having more northern declination than the apex) as at *s*, its northern declination will increaſe, and it will alſo fall within the nodated part of the conchoid *Ax*P*y*; but when its diſtance from the interſection *m* is more than 90 degrees, as at S, the motion will be towards the ſouth, and the ſtar will be ſituated without the nodated part of the curve. That the ſtar *s* will fall within the nodated part appears becauſe *ms* being leſs than *mn* by ſuppoſition, if *m* be drawn towards E, to deſcribe the conchoid the angle A*m*Q will decreaſe, and therefore the deſcribing point *n* will be depreſſed below *s* as it approaches A. For the ſame reaſon S will fall without; ſince, by drawing *m* towards Q, the angle A*m*Q will become greater than S*m*Q, and the deſcribing point *n* will paſs above the ſtar S. The application of this theory is very ſimple; for inſtance, let it be required to find whether any given ſtar will fall within or without the conchoid. Then, in fig. 6, there will be given P*s*, the polar diſtance of the ſtar; and QP*c*, the difference of right aſcenſion between the ſtar and the apex of the ſun's motion A; alſo, the polar diſtance PA, and declination *c*A of the point A. Then, by trigonometry, the ſides *s*P, PA, and the included angle being given, we find the ſide A*s* and angle PA*s*. Again, the ſide *c*A, and angle *c*A*m*=PA*s* of the right-angled triangle A*cm* being given, we find the hypothenuſe A*m*; and if A*m*+A*s* be leſs than 90 degrees, the ſtar falls within the conchoid, otherwiſe without.

It will be found, that I have placed the want of ſenſible motion of α Lyræ and α Orionis in right aſcenſion, and of Rigel both in right aſcenſion and declination to the account of thoſe ſtars that are in favour. Theſe ſtars are ſo bright, that we may reaſonably ſuppoſe them to be among thoſe that are neareſt to us; and if they had any conſiderable motion, it would moſt likely have been diſcovered, ſince the variations of Sirius, Arcturus, Procyon, Caſtor, Pollux, &c. have not eſcaped our notice. Now, from the ſame principle of the motion of the ſolar ſyſtem, by which we have accounted for the apparent *motion* of the latter ſtars, we may account for the apparent *reſt* of the former. Thoſe two bright ſtars, α Lyræ and α Orionis, are placed ſo near the direction of the aſſigned ſolar motion, that from the application of my ſecond theorem (p. 261. of the paper on the Motion of the Solar Syſtem) their motion ought to be inſenſible in right aſcenſion, and not very conſiderable in declination, all which we find is confirmed by obſervation. With reſpect to Rigel and α Serpentarii, admitting them both as ſtars large enough to have ſhewn a proper motion, were their ſituation otherwiſe than it is, we find that they alſo ſhould be apparently at reſt in right aſcenſion; and Rigel having ſouthern declination, and being a leſs conſiderable ſtar than α Orionis, which ſhews but 11″ motion towards the ſouth in 50 years, its apparent motion in declination may, on that account, be alſo too ſmall to become viſible.

I ſhould not omit to take notice of a very remarkable paragraph of MAYER's, which ſeems to contain a ſtrong objection againſt the motion of the ſolar ſyſtem, while indeed it may be ſhewn to be a very good argument in its favour. At the end of his tract, De Motu Fixarum, he ſays: "Tandem, quum et quæri "poſſit, quæ hujus motus cauſa ſit, hoc unum monere viſum,

" illum explicare non poſſe per motum totius ſyſtematis ſo-" laris, et ſi nec impoſſibile ſit, ſolem, ut ejuſdem cum fixis " naturæ, inſtar harum quarundam in ſpatio mundano pro-" moveri. Nam ſi ſol et cum ipſo planetæ omnes noſtrumque " domicilium terra, recta tenderent verſus plagam aliquam, uni-" verſæ fixæ, quæ in ea plaga adparent paullatim a ſe invicem " diſcedere, et quæ ſunt in oppoſita parte coeli coire viderentur; " non ſecus ac per ſilvam ambulanti arbores, quæ ante viam " ſunt, disjungi videntur, quæ a tergo, congredi." Now, if we recollect what has been ſaid of the motion of the ſtars, we find, that thoſe, towards which I ſuppoſe the ſolar ſyſtem to move, do really recede from each other: for inſtance, Arcturus from α Lyræ; α Aquilæ and α Aquarii from α Serpentarii and ε Urſæ majoris; and, on the contrary, thoſe in the oppoſite part of the heavens do really come nearer to each other; as Sirius to Aldebaran; Procyon to α Arietis; Caſtor, Pollux, Regulus, &c. to α Ceti, α Perſei, α Andromedæ, &c. All this agrees with what MAYER ſays ought to happen, if the ſolar ſyſtem was to have a motion towards a certain part of the heavens; which, by the bye, I find this admirable aſtronomer mentions as a very poſſible thing*. However, when he ſays that *all the ſtars* in thoſe parts towards which the ſun might be ſuppoſed to move, ſhould recede from each other, and *vice verſâ*; I muſt add, that this would only take place under the reſtrictions of my firſt, ſecond, and third theorems, and therefore it is not to be expected, that we ſhould immediately ſee the effect of this parallax in any but the ſtars that are neareſt to us. But as we have at preſent no other method of judging of the relative diſtance of the fixed ſtars than from their apparent brightneſs,

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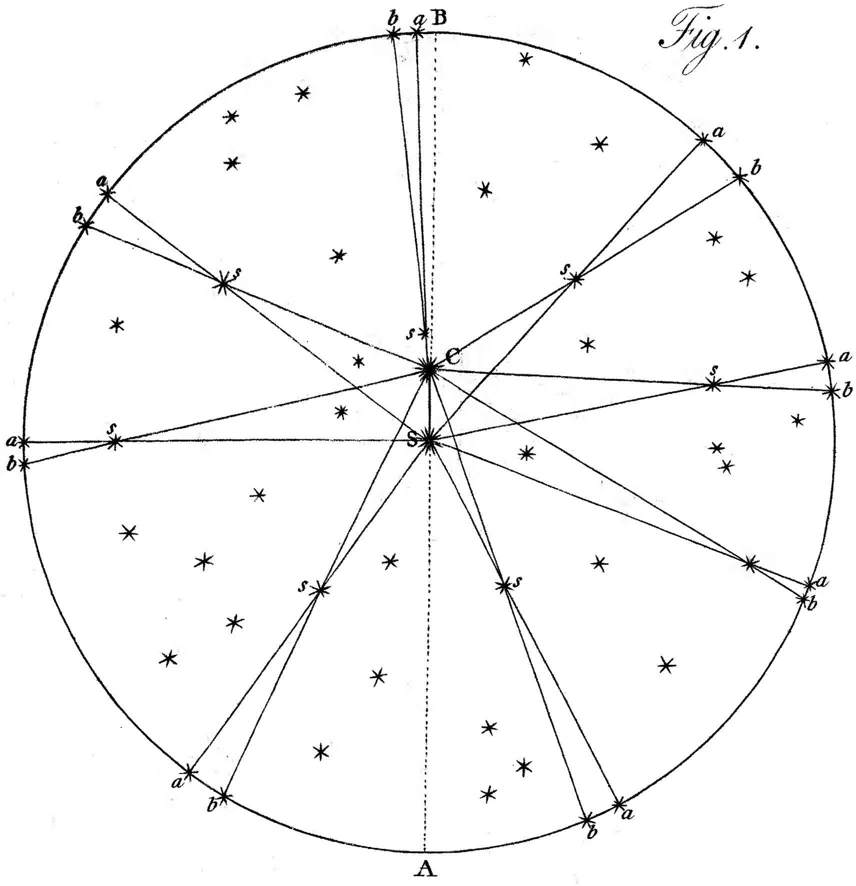
[*] This paper, De Motu Fixarum, was read at Gottingen in January 1760.

Fig. 1.



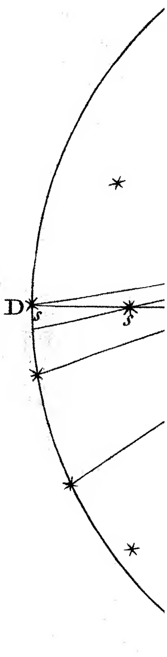


Fig. 2.

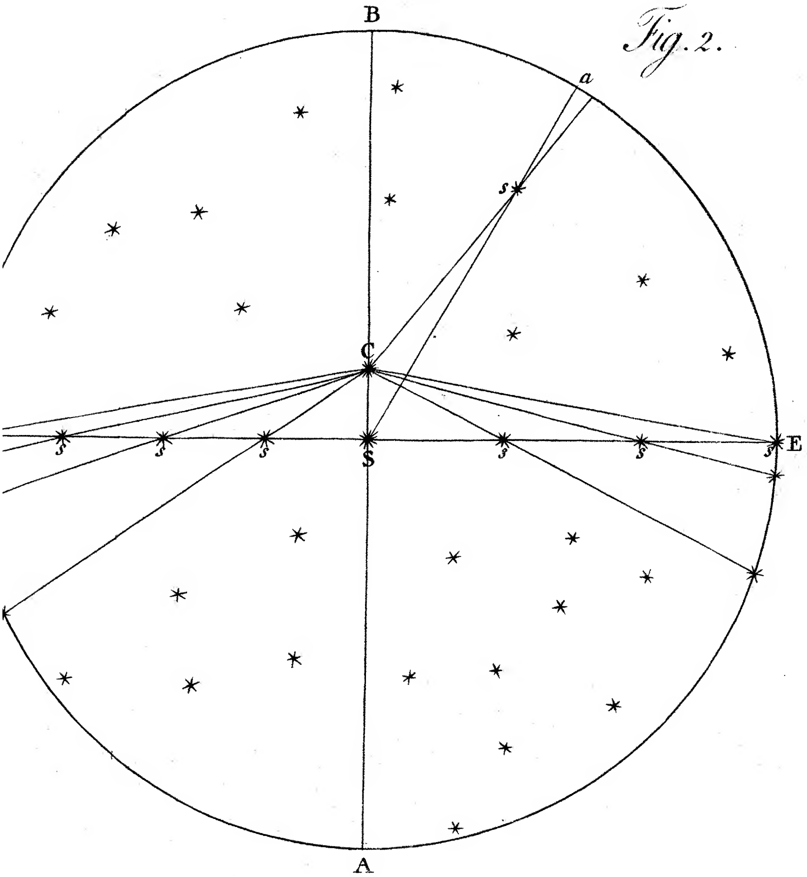


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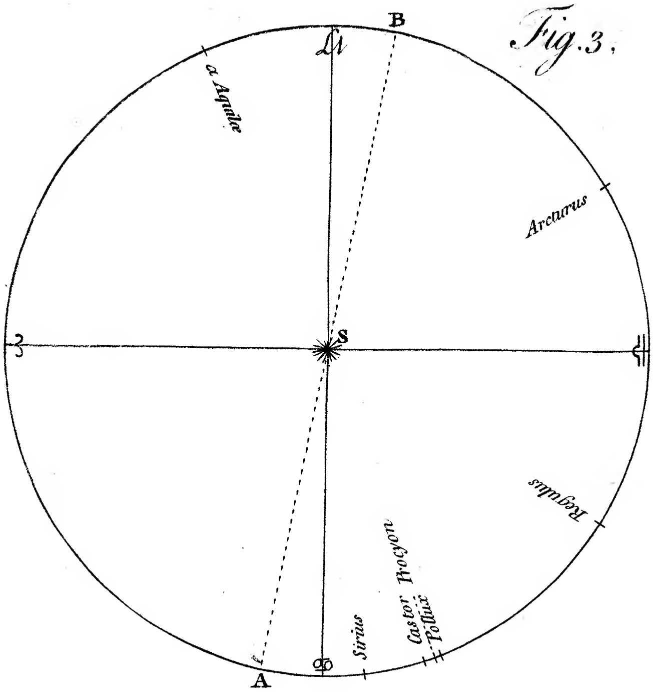
Fig. 3.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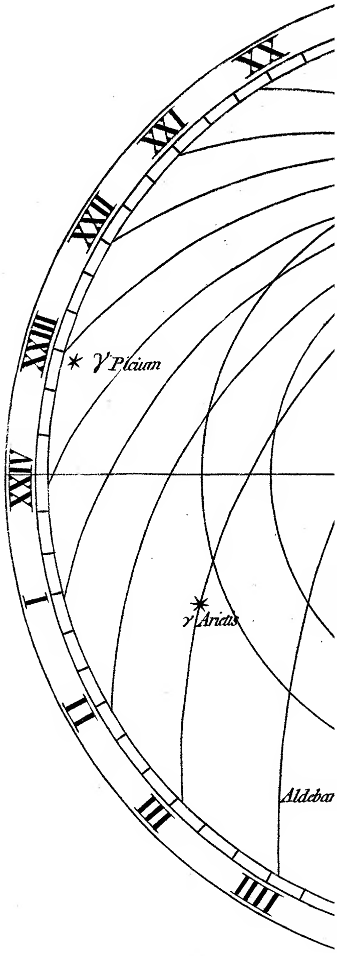
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Aldeba
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Fig. 4.

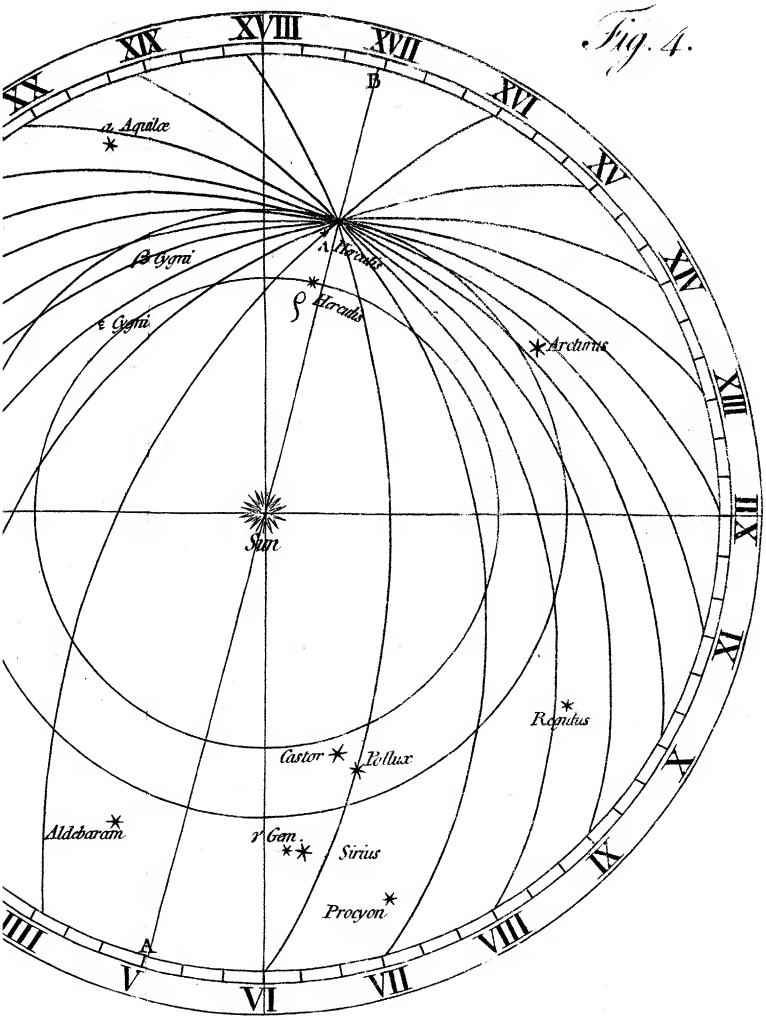

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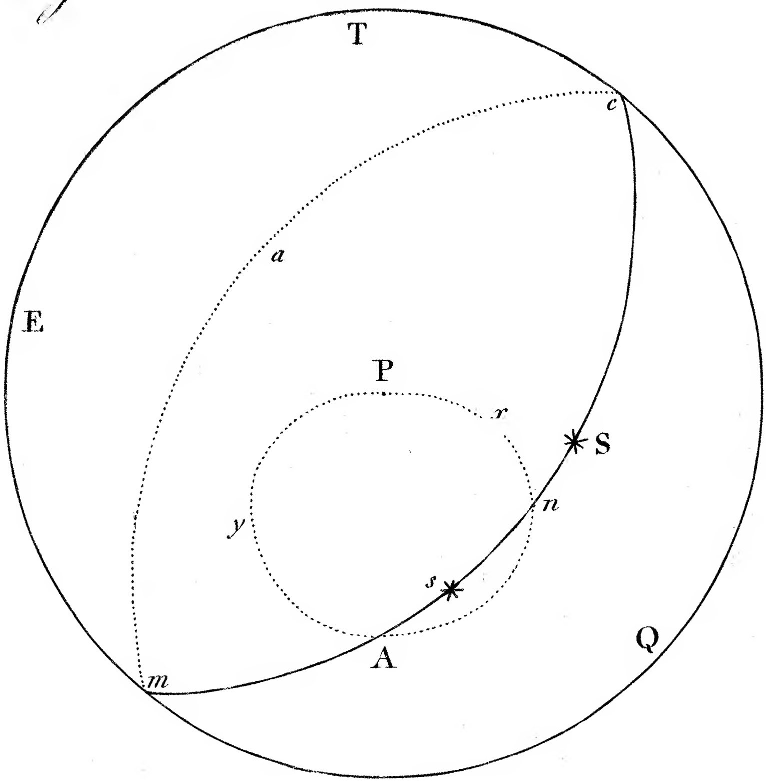
Fig. 5.



Philos. Trans. Vol. LXXIII. Tab. VI. p. 282.

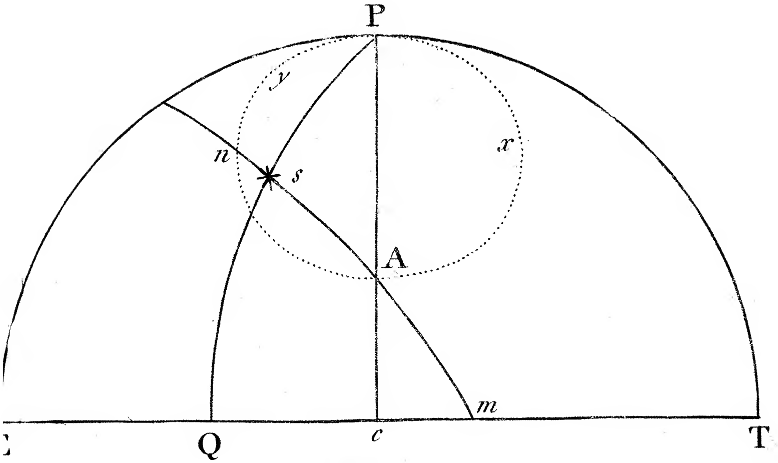


Fig. 6.

Basire sc.

neſs, thoſe that are moſt likely, on that account, to be affected by a parallax ariſing from the motion of the ſolar ſyſtem, are the very ſtars which, by MAYER's own table, I have made uſe of to point it out to us *.

Datchet, March 13, 1783.

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* I have lately been favoured by Dr. WILSON, Profeſſor of Aſtronomy at Glaſgow, with a ſhort tract, called, "Thoughts on general Gravitation, and Views "thence ariſing as to the ſtate of the Univerſe;" wherein the poſſibility of a Solar Motion is alſo ſhewn. It was printed in 1777. Mr. DE LA LANDE, in the Memoirs for 1776, with his uſual felicity of thought, has inferred the probable motion of the ſyſtem from the ſun having a rotation round his axis, when he ſays, p. 513. "Une force quelconque imprimée à un corps, et capable de le "faire tourner autour de ſon centre, ne peut manquer auſſi de déplacer le centre, "et l'on ne ſauroit concevoir l'un ſans l'autre. Il paroit donc très-vraiſemblable "que le ſoleil a un mouvement réel dans l'eſpace abſolu," &c.

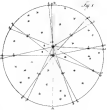

Fig. 1

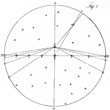

Fig. 2

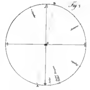

Fig. 3

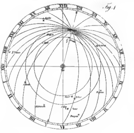

Fig. 4

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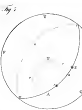
Castor
Pollux
Procyon

Fig. 5



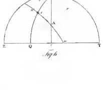


Fig. 6